Groundwater Remediation
The goal of groundwater remediation is to restore the groundwater to its potential beneficial uses- in turn, protecting human health and the environment, controlling plume migration, and protecting the Columbia River.

Groundwater Glossary

Groundwater is water filling in the cracks or pores between rocks or grains of sand at varying depths below ground surface.

An **aquifer** is an area where water moves easily, and its pores are completely saturated, much like a sponge full of water.

Confined aquifers are areas where the aquifer is contained between impervious (solid) layers.

Unconfined groundwater moves through saturated layers in the ground, slowly working its way in or out of the earth. Depending on the geology of an area, groundwater may rise to the surface through springs, or seeps; flow laterally into nearby rivers, streams, or ponds; or sink deeper into the earth.

The top of an unconfined aquifer is known as the **water table**. The **vadose zone** is the area between ground surface and the water table.

Groundwater is replaced or "recharged" from the surface, or from nearby rivers, lakes, or streams. Some groundwater recharge occurs quickly, some occurs slowly. If too much water is pumped from wells, recharge by natural precipitation or surface water flows may not be enough to maintain the water level. Groundwater can also build up, or mound, in areas where water used for industry or irrigation is discharged to the ground. Hanford had several areas where groundwater mounded as facilities discharged water to the ground.

Groundwater at Hanford generally flows from west to east, or toward the Columbia River. As facilities closed, groundwater mounds diminished, lowering water tables. Recently, water tables in the 200 Area have dropped, changing groundwater flow in some places or leaving monitoring wells high and dry. Some wells have been replaced with deeper wells.

Once groundwater becomes contaminated it is difficult and costly to remediate. Therefore, the best way to protect the groundwater is to prevent any future contamination.
C3T Groundwater Strategy

Properly disposing of contaminated soil prevents further deterioration of groundwater.

This is the first in a series of educational brochures about Hanford's groundwater.

The remaining brochures explain available remediation techniques, and provide case studies of both successful and problematic groundwater cleanup actions.

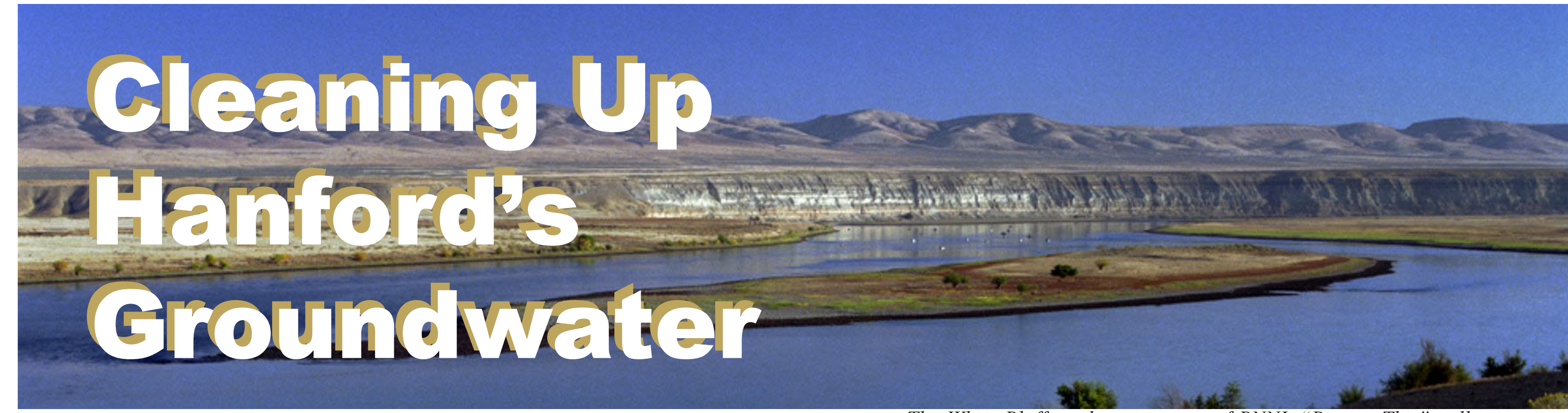
The "In-Situ Redox Manipulation" process uses an innovative chemical process to immobilize groundwater contaminants below ground surface. In-situ, or on site treatment allows cleanup without having to remove the groundwater for treatment.

Tri-Party Agreement

Call the Hanford Cleanup Line at 1-800-321-2008 for more information.

Ecology Publication Number 02-05-015

Cleaning Up Hanford's Groundwater



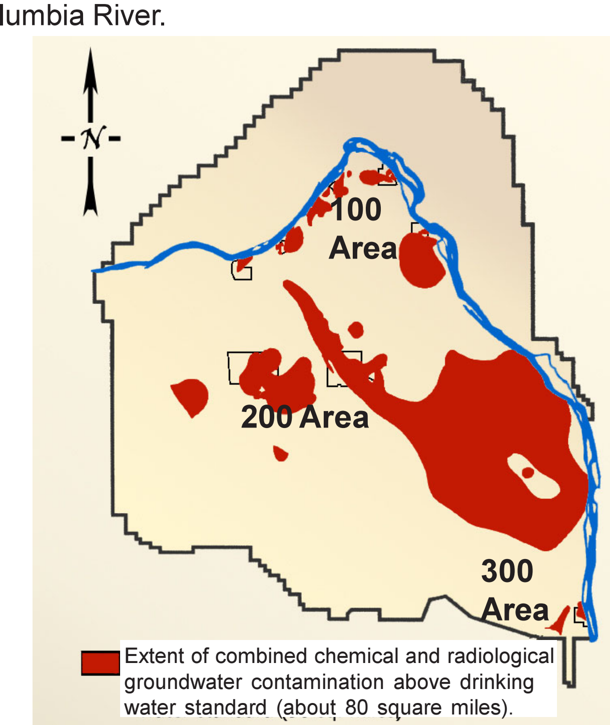
The White Bluffs - photo courtesy of PNNL "Picture This" collection.

Hanford's Groundwater Remediation Strategy

Tri-Party Agencies (U.S. Dept. of Energy, U.S. Environmental Protection Agency, and Washington State Dept. of Ecology) and Hanford contractors jointly developed a strategy for protecting Hanford's groundwater. The strategy is focused on protecting the Columbia River by controlling migration of existing contaminant plumes, developing new technology, remediating contaminated areas, and improving Hanford's monitoring efforts.

Hanford History

As part of the Manhattan Project- the United State's effort to build the first atomic bomb- the Hanford area was selected for producing plutonium for nuclear weapons. Hanford continued producing plutonium during the "Cold War" creating huge amounts of liquid and solid waste. In some areas, waste was disposed of directly to the soil. In other areas, facilities, and/or tank waste leaked through the soil and reached the groundwater. Unfortunately, some contaminants have reached the Columbia River.



Key Elements of Hanford's Groundwater Remediation Strategy

1. Place a high priority on actions that protect the Columbia River and near-shore environment from degradation.
2. Control the migration of plumes that threaten or continue to degrade groundwater quality beyond the boundaries of the Central Plateau.
3. Develop and deploy alternative remediation technologies where needed.
4. Avoid recontamination of the sites already cleaned-up, or those currently undergoing remediation.
5. Integrate all site monitoring needs to determine required actions.

Proposed Initiatives in the Strategy

1. Optimize current groundwater remediation systems, such as pump and treat, to maximize benefits.
2. Identify, characterize, and remove or immobilize the possible sources of contamination from the vadose zone, using excavation or innovative technologies to prevent the spread of contaminants.
3. Protect the rivershore.
4. Close abandoned wells in vicinity of waste sites.
5. Promote, develop, and implement new technologies for cleaning groundwater.

Sources of Groundwater Contamination

Groundwater Facts
About 80 square miles of Hanford's groundwater has contaminant levels above federal and state drinking water standards. Some of those pollutants have reached the Columbia River.

The major chemical contaminants include nitrate, chromium, and carbon tetrachloride. Major radioactive contaminants include, uranium, technetium-99, tritium, strontium-90, and iodine-129.

What's a pico-Curie?
A Curie is a unit of radioactivity- the amount of any nuclide that undergoes exactly 37 billion radioactive disintegrations per second. Pico means one trillionth, or 10^{-12}. Concentration of radionuclides in groundwater is measured in pico-Curies per liter (pCi/L).

What's a Half-Life?
The radioactive half-life for a given radioisotope is the time for half the radiation to decay. After two half-lives, there will be one fourth the original radiation, after three half-lives one eighth the original radiation, and so forth.

Reverse Wells
Also known as injection wells, reverse wells served as disposal areas for liquid contaminants by pumping them directly back into the soil.

Pits, Burial Trenches & Landfills
Solid and liquid wastes in barrels were buried in trenches, pits, or unlined landfills. As the containers break down, contaminants enter the soil.

Underground Storage Tanks
There are 177 tanks at Hanford storing more than 53 million gallons of high and low-level waste. Sixty-seven single shell tanks are known, or suspected to have leaked. It is estimated that past releases have amounted to about 1 million gallons.

Cribs, Ponds, Trenches & French Drains
Cooling and waste water was directed to storage ponds, trenches, cribs or French drains (perforated pipes allowed liquid to release into rock-lined, soil-covered trenches).

How Are Chemicals Measured?
Organic and inorganic chemicals are measured in parts per million (ppm), or billion (ppb) in a liter of water. Sometimes ppm is used interchangeably with milligrams per liter (mg/L).

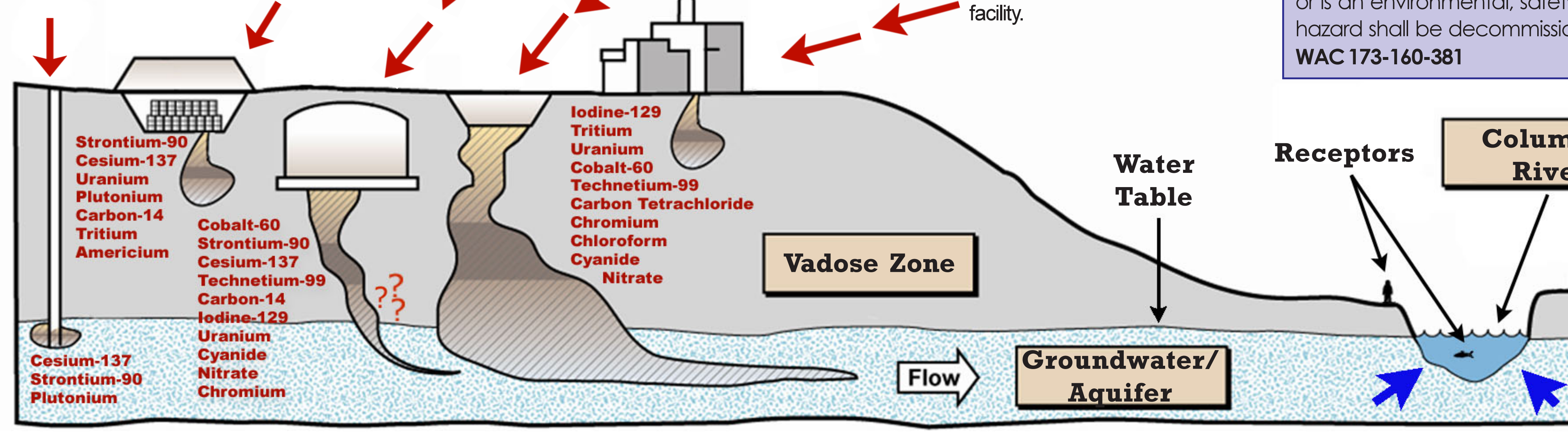
Plant Waste Discharge
Some facilities at Hanford disposed of waste directly to the soil outside the facility.

What Does the Law Say?
Washington State's Model Toxics Control Act (MTCA) requires cleanup levels to be based on highest beneficial use of groundwater.

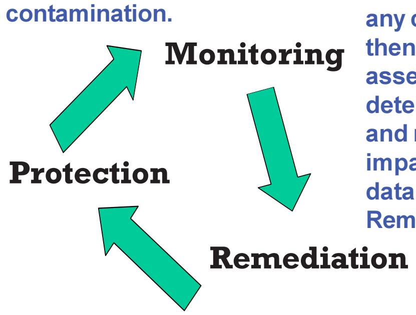
The protection of subterranean water from pollution or degradation is of great concern.
RCW 36.36.010

It is the intent of the legislature to work closely with the executive branch, Indian tribes, local government, and interested parties to ensure that water resources of the state are wisely managed.
RCW 90.54.010

Any well which is unusable, abandoned, or whose use has been permanently discontinued, or which is in such disrepair that its continued use is impractical or is an environmental, safety or public health hazard shall be decommissioned.
WAC 173-160-381



Monitoring measures how effective protection is in its end goal and ensures early warning in case of contamination.



If monitoring detects any contamination, then scientists will assess the site to determine the extent and magnitude of the impact and to gather data to help with Remediation.

Remediation protects by mitigating any further degradation of the groundwater and by removing or immobilizing the current contamination.

For more information on Hanford groundwater issues please surf over to the report, **Hanford Site Groundwater Monitoring for Fiscal Year** at **http://hanford-site.pnl.gov/2001**.

Carbon Tetrachloride
Carbon tetrachloride, an organic chemical, is found in the 200 West Area and contaminates about 4.2 square miles of groundwater. is contaminated above drinking water standards. The drinking water standard is 5 ppb. It hasn't been found in wells near the Columbia River. Studies indicate contaminants may reach the Columbia River sometime in the future. Remediation to control plume expansion and migration of carbon tetrachloride is underway.

Chromium
Chromium, an inorganic chemical, contaminates one square mile of groundwater near H, D, and K Reactors in the 100 Area. Hanford is persuing a more stringent cleanup than required by the drinking water standard . Chromium has entered the Columbia River. Remediation of chromium has successfully reduced toxicity and is slowing the flux of chromium contam-ination entering the river.

Iodine-129
In the 200 East area, iodine-129 contaminates about 33 square miles of groundwater. The drinking water standard is 1 pCi/L. Remediation technology is not currently available.

TEXT COLOR KEY
- area of contamination
- remediation unavailable
- remediation underway

Nitrates
Nitrates are an inorganic contaminant. About 16 square miles of Hanford groundwater are contaminated with nitrate. The drinking water standard for nitrates is 45 ppm, or as nitrogen is 10 ppm. Nitrate contamination has reached the Columbia River. Average contamination is slightly above drinking water standard. Large scale remediation of nitrate from groundwater is impractical. Hanford is not the main source of nitrates to the river.

Strontium-90
Strontium, a radioactive contaminant, pollutes a square mile of groundwater, mostly in the vicinity of the N Area, and 200 East Area. Strontium-90 has entered the Columbia River. The drinking water standard is 8 pCi/L. Remediation is underway and has reduced the flux of strontium-90 entering the river.

Technetium-99
Technetium-99 is a long-lived radionuclide. In the 200 West Area, technetium-99 contaminates about a square-mile. The drinking water standard is 900 pCi/L. Studies show that technetium-99 may reach the Columbia River in the future. Remediation is underway to control plume expansion.

Tritium
Tritium is a radioactive contaminant. The largest tritium plume originates in the 200 East Area, however, it is found throughout Hanford groundwater. About 70 square miles are contaminated, and it has entered the Columbia River. The drinking water standard for tritium is 20,000 pCi/L. Remediation technology is not currently available. However, tritium has a short half-life, so natural decay will play a major role in reducing contamination over time.

Uranium
Uranium contaminates about a square mile of groundwater in the 200 West Area and 300 Area. The 300 Area plume has entered the Columbia River. The drinking water standard is 27 pCi/L. Interim remediation to remove uranium is being conducted in the 200 West Area. In the 300 Area, natural attenuation for uranium is implemented.

Major Types of Groundwater Contamination